

Asymmetry of Jet k_T in Longitudinal Polarized p+p Collisions in PHENIX at RHIC

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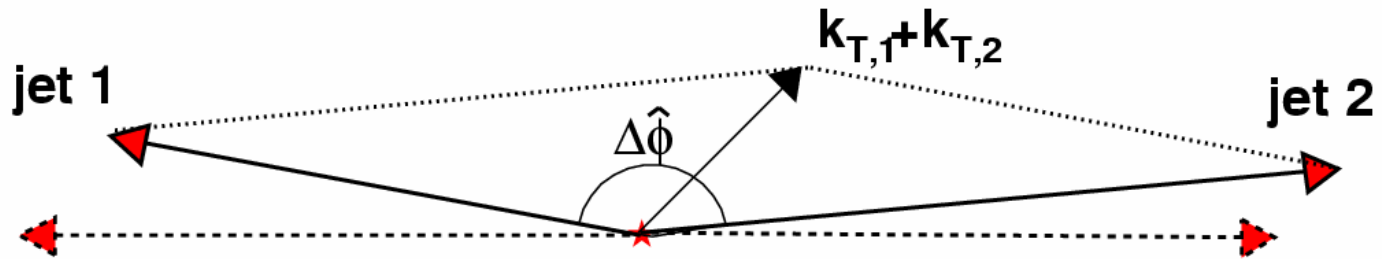
For the PHENIX collaboration

University of New Mexico

Outline

- Measuring transverse momentum of partons in the proton
- Looking for a correlation of this measurement with spin direction
- Initial measurements in Run03
- Status of Run05
- Summary

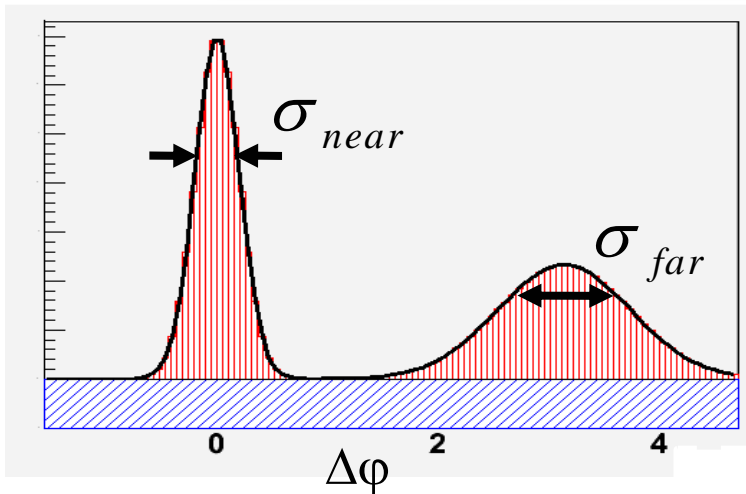
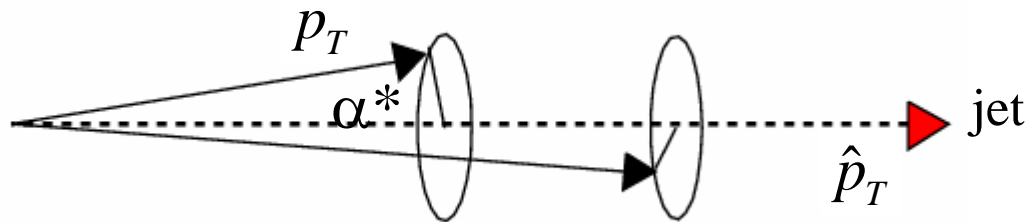
k_T, j_T from azimuthal correl.



$$j_T = \hat{p}_T \sin(\alpha^*)$$

fragmentation

$$z = \frac{p_T \cos(\alpha^*)}{\hat{p}_T}$$



$$\langle j_T \rangle \propto \sigma_N$$

jet fragmentation transverse momentum, j_T -scaling.

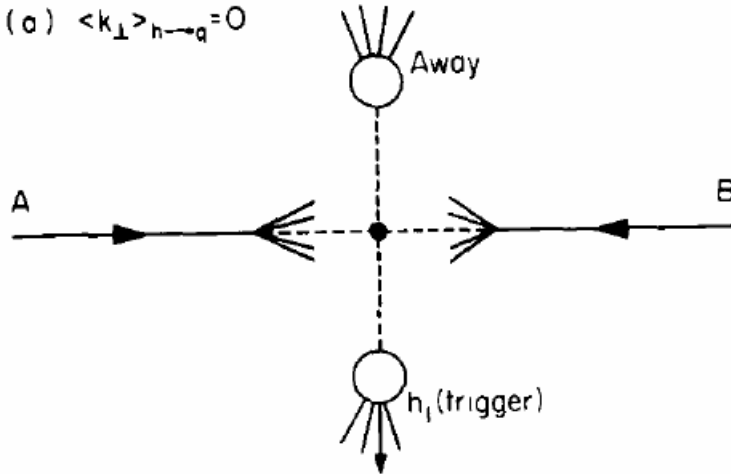
$$\langle k_T \rangle \propto \sqrt{\sigma_F^2 - \sigma_N^2}$$

parton transverse momentum, intrinsic + NLO radiative corrections.

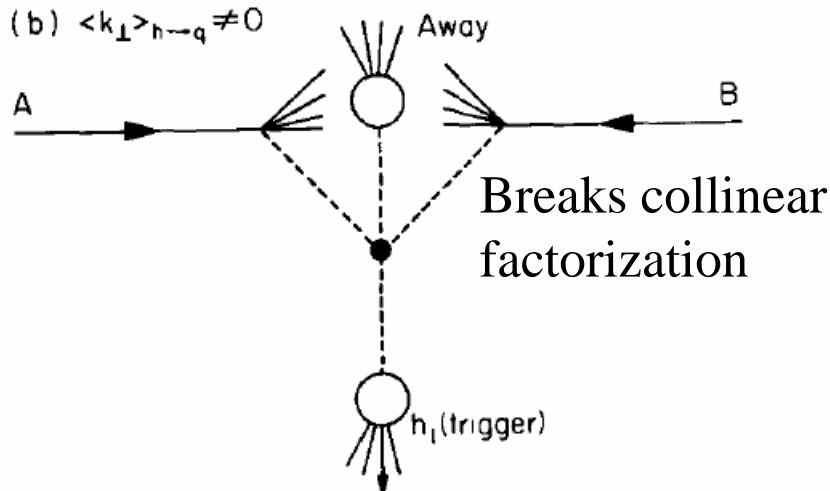
Origin of k_T

$$\frac{1}{2} \langle p_T^2 \rangle_{pair} = \langle k_T^2 \rangle = \langle k_T^2 \rangle_{intrinsic} + \langle k_T^2 \rangle_{soft} + \langle k_T^2 \rangle_{NL O}$$

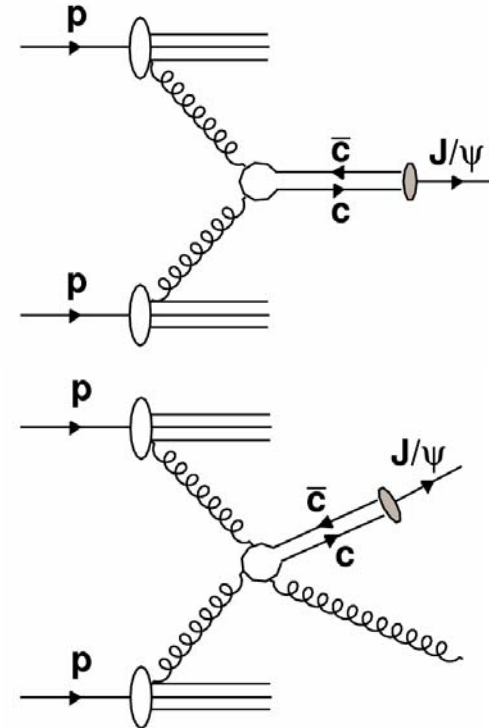
(a) $\langle k_{\perp} \rangle_{h \rightarrow q} = 0$



(b) $\langle k_{\perp} \rangle_{h \rightarrow q} \neq 0$



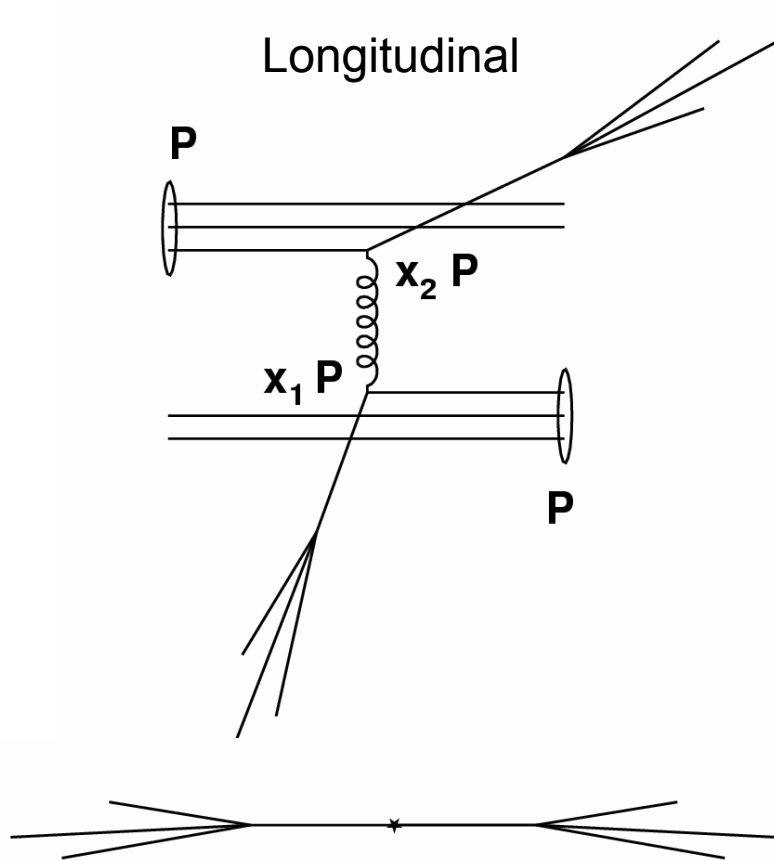
An example - J/ ψ production.



$$\langle p_T \rangle_{J/\psi} = 1.8 \pm 0.23 \pm 0.16 \text{ GeV}/c$$

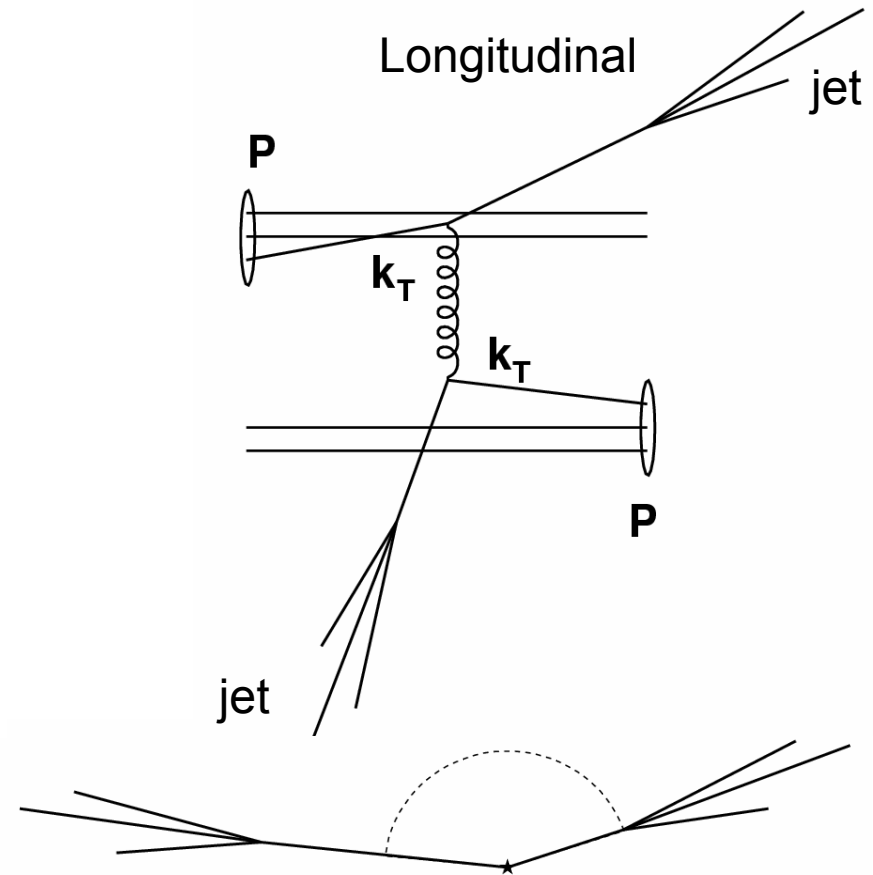
Phys. Rev. Lett. 92, 051802,
(2004).

Hard Scattering k_T



transverse

- acoplanar in $P_L \times P_T$ space
- **collinear** in $P_X \times P_Y$ space



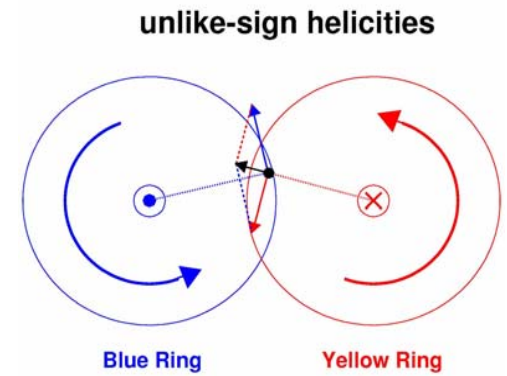
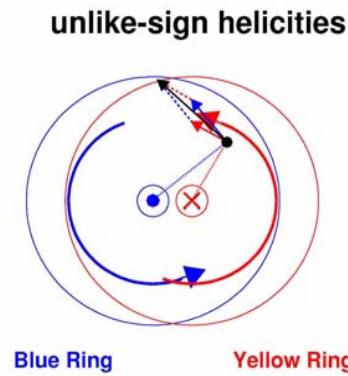
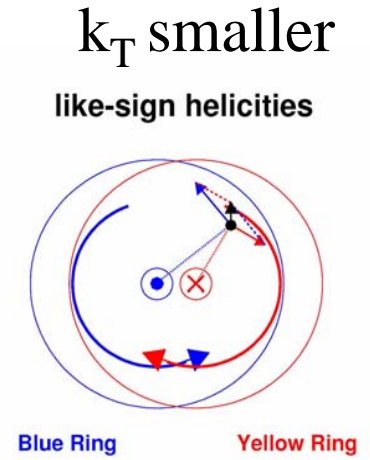
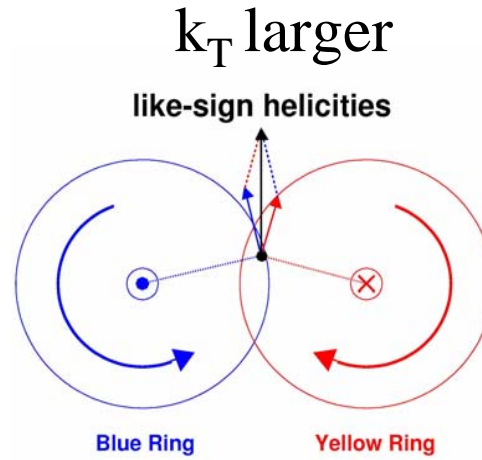
transverse

- acoplanar in $P_L \times P_T$ space
- **acoplanar** in $P_X \times P_Y$ space

k_T from Orbital Motion

One can consider the possibility that spin-correlated transverse momentum (orbital angular momentum) may contribute to jet k_T .

e.g., Meng Ta-chung et al.,
Phys. Rev. D 40 (1989)

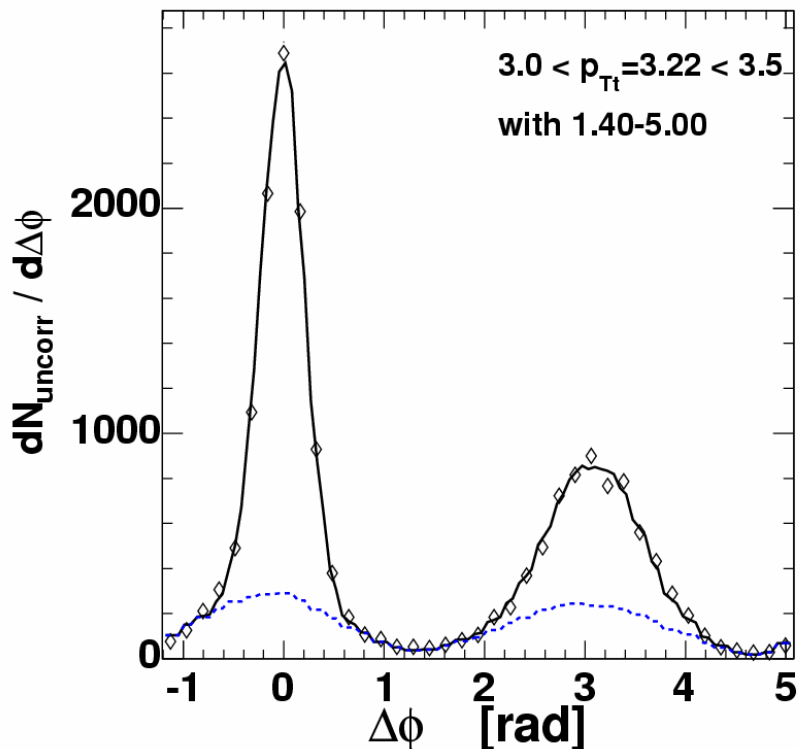


Azimuthal correlation function

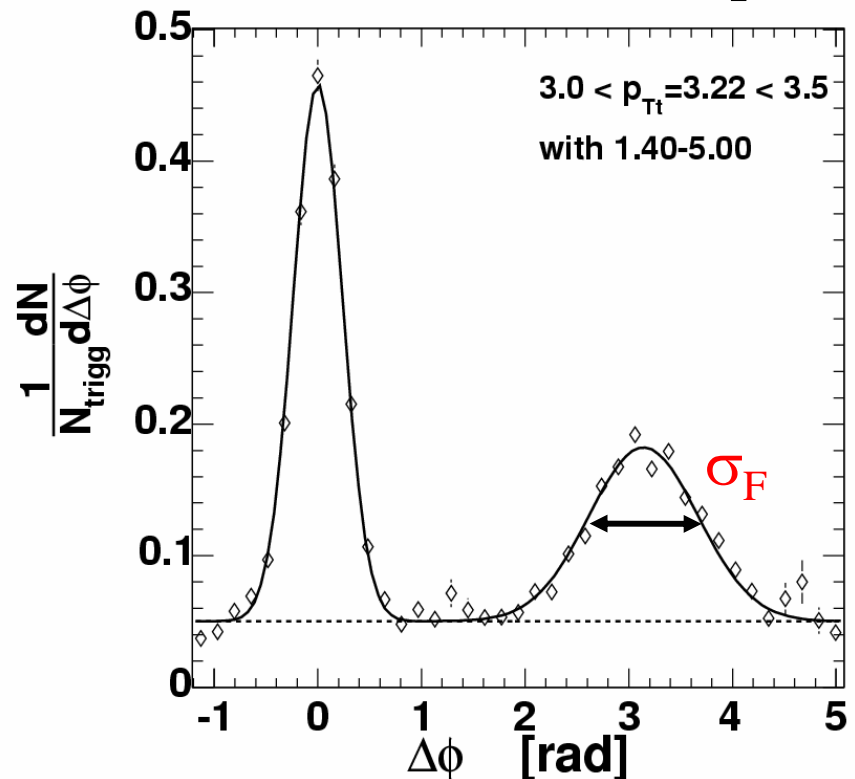
$$C_{ij}(\Delta\phi) = \text{norm} \left| \frac{dN_{ij}^{\text{real}}}{d\Delta\phi_{ij}} \right| / \frac{dN_{ij}^{\text{mixed}}}{d\Delta\phi_{ij}}$$

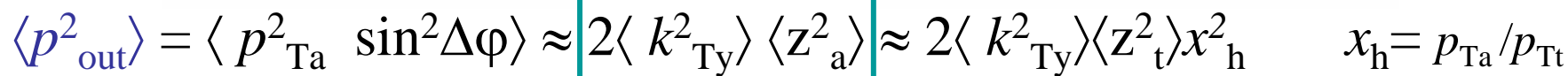
$\pi^0 - h^\pm$ correlation functions

Not corrected for acceptance



Corrected for acceptance





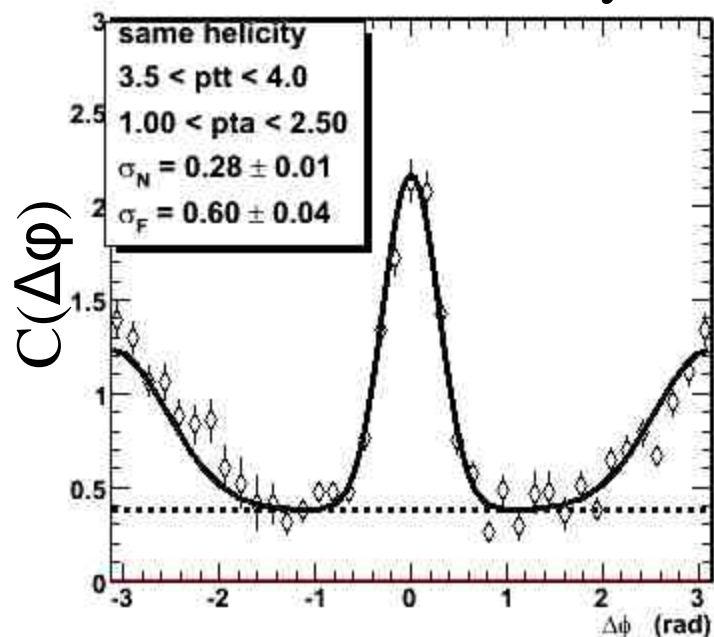
$$\text{partonic } \hat{x}_h = \frac{\langle \hat{p}_{Ta} \rangle}{\langle \hat{p}_{Tt} \rangle}$$

$$\text{hadronic} \quad x_h = \frac{p_{Ta}}{p_{Tt}}$$

Spin Sorted Analysis

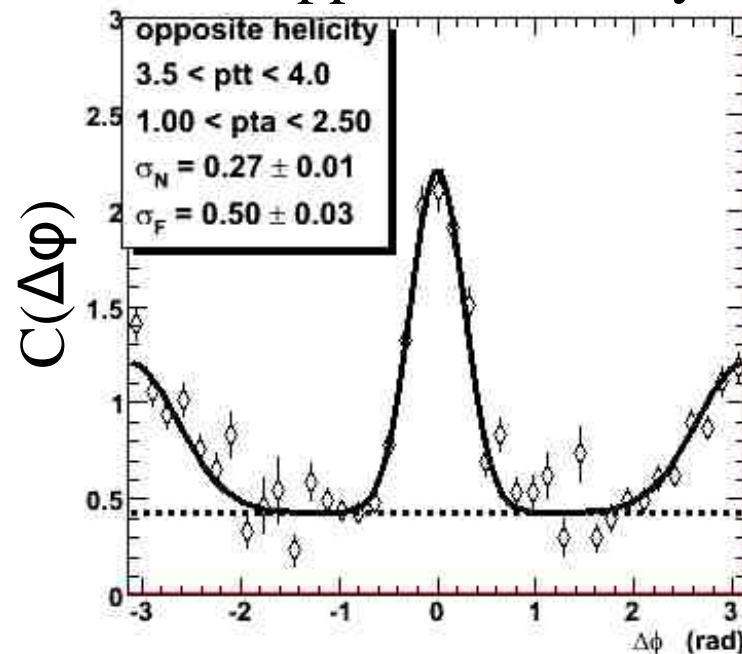
- Do exactly the same analysis sorted on same and opposite helicity bunch crossings, extract $\langle zkt \rangle_{\text{RMS}}$ and look at the difference.

Same Helicity



$\Delta\phi$

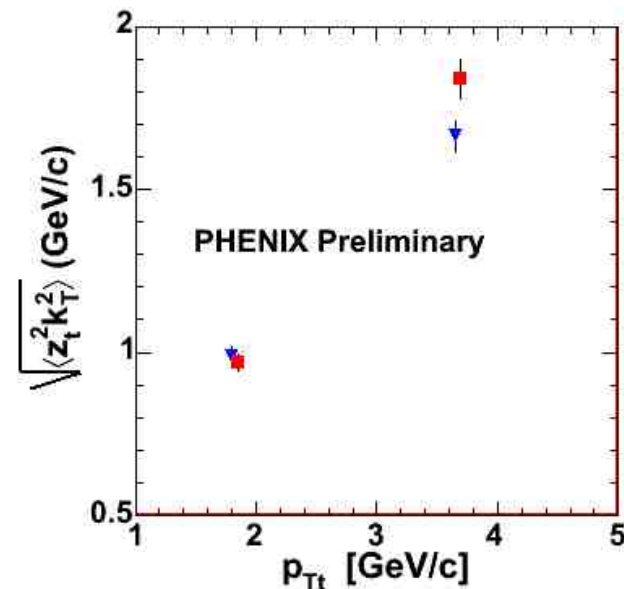
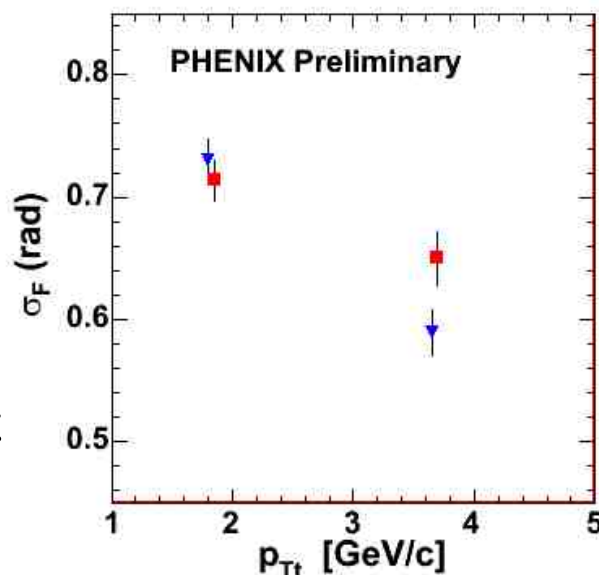
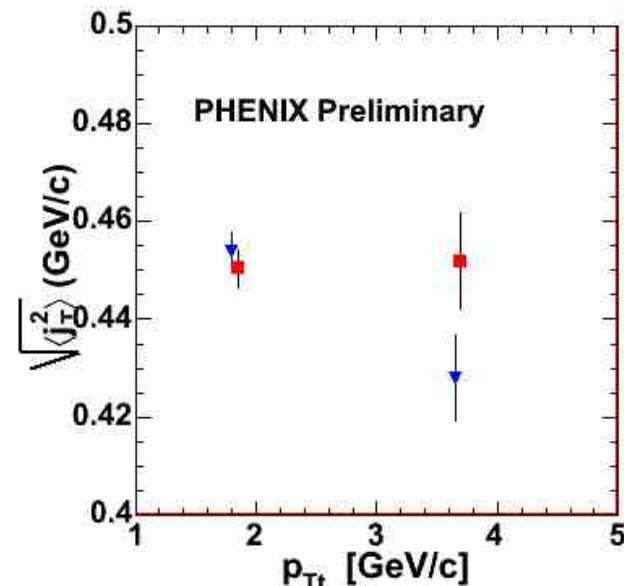
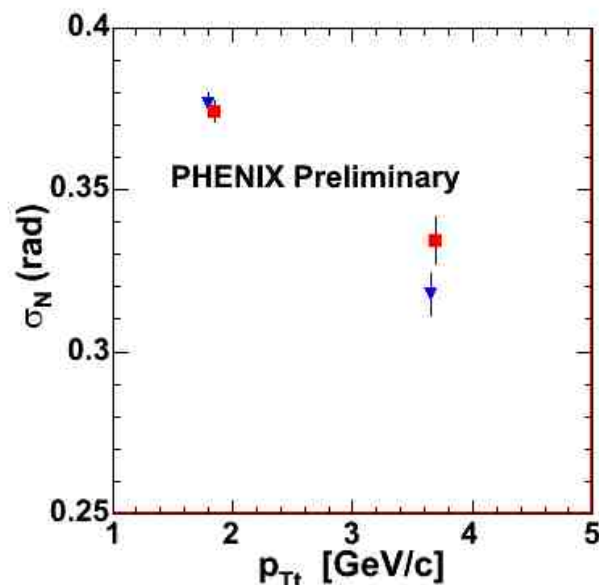
Opposite Helicity



$\Delta\phi$

Like sign

Unlike sign



trigger π^0

$1 < p_{T\uparrow} < 3 \text{ GeV/c}$

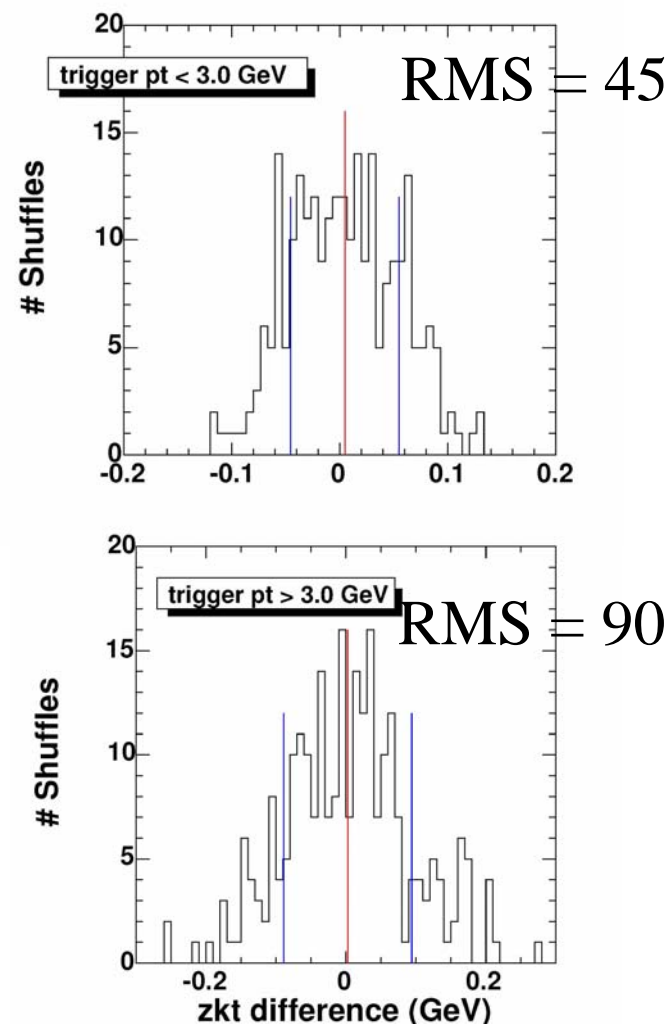
$3 < p_{T\uparrow} < 7 \text{ GeV/c}$

Associated h^\pm

$1 < p_{Td} < 2.5 \text{ GeV/c}$

Systematic Check

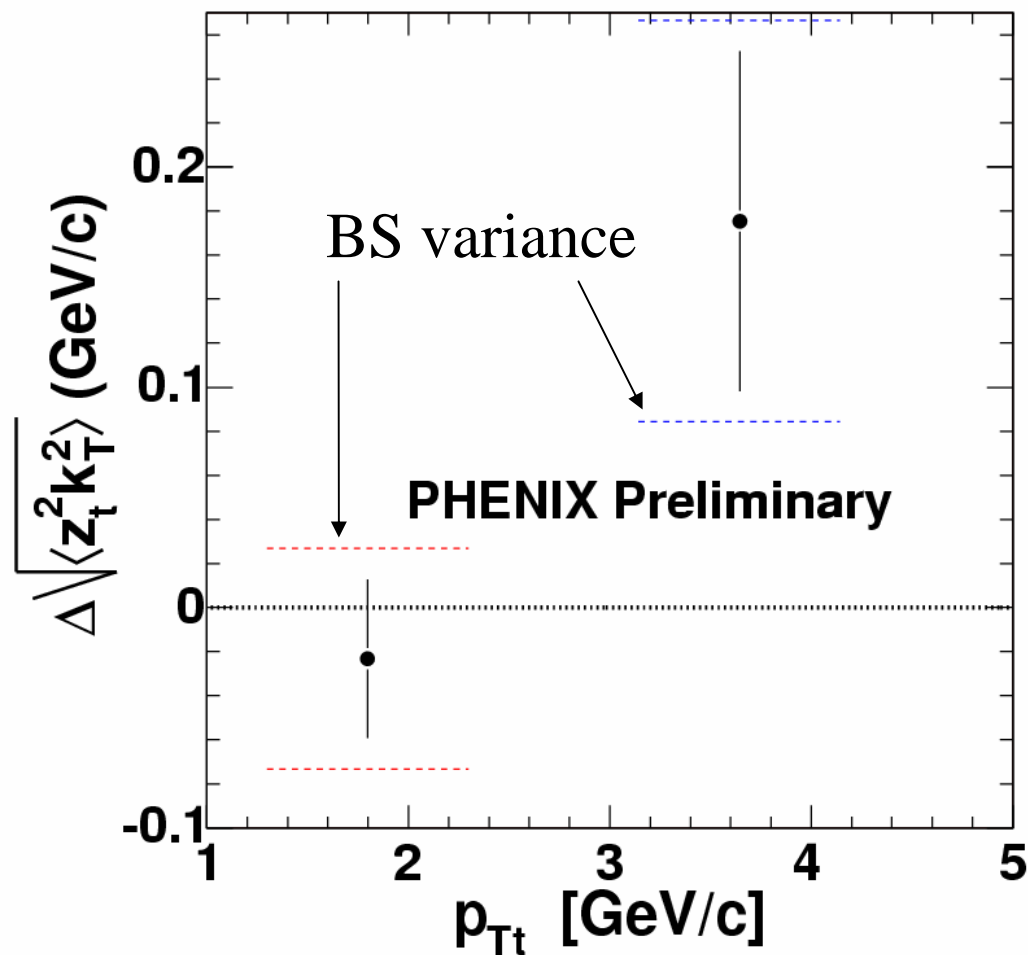
- Helicity assignments are randomized, and then the k_T difference calculated for each randomized set.
- The width of the distribution for all the randomized sets should be the same as our statistical errors on the previous plot.



Run03 Data

It's too early to make a definite statement about the apparent excess as the systematic uncertainties are being evaluated.

However, there is an ongoing analysis of 10x more stat. and 2x better polarization in run05 → should yield a definite answer.



Summary

- We have an **analysis tool** that allows us to measure k_T - initial state transverse momentum of partons.
- We are studying this effect in **longitudinal spin-sorted collisions** to see if there is a spin-dependent **coherent** component of k_T .
- Is there a **connection** to **parton OAM**?
Theoretical guidance needed!

Outlook

- Run05 has **$\sim x10$ statistics**, so that the uncertainty **reduced** by factor **2-3**.
- It has **$\sim x2$** in polarization, so the effect grows by **$\sim x4$** .